Cloud-Resolving Simulations of 28 July 2002 Case

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OUTLINE

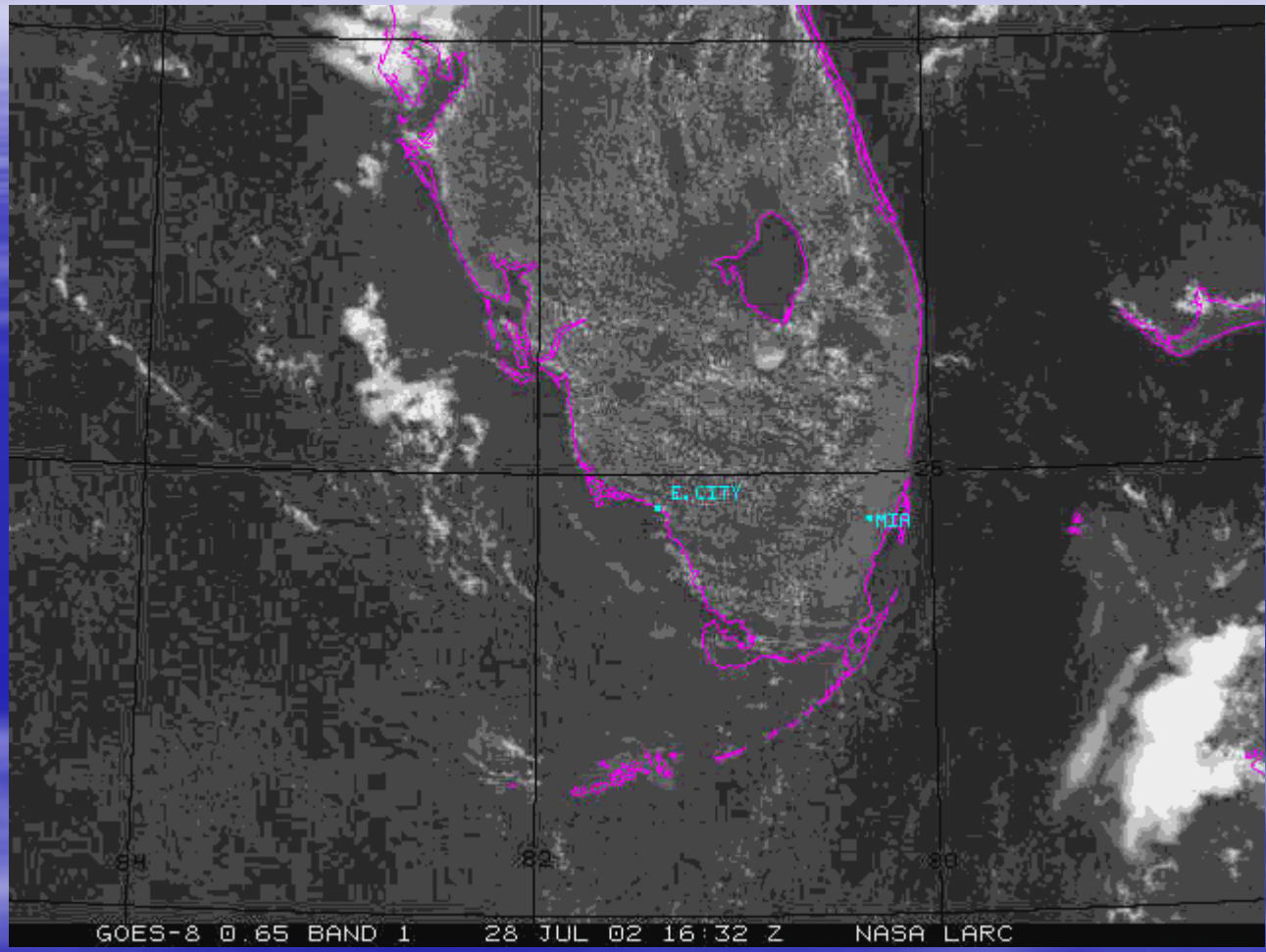
- Goals
- Case Study
- Model Description
- Results
- Future Work

Goals

- Cloud dynamics of the different stages of storm development from the convective stage to the anvil stage, and the relationship between them
- Transport and activation of cloud nucleating aerosol (CCN/GCCN/IFN) and the cloud processing of these aerosol
- Growth and transport of various water species and the general evolution of the hydrometeor size spectra during the different stages of storm development
- Role of these tropical convective systems in the vertical and horizontal transport of water vapor

CASE STUDY: 28 July 2002

- Easterly wave over the southern regions of the Florida peninsula
- Presence of Saharan dust
- Storms along W coast in the regions of Everglade City, Fort Meyers, and Tampa

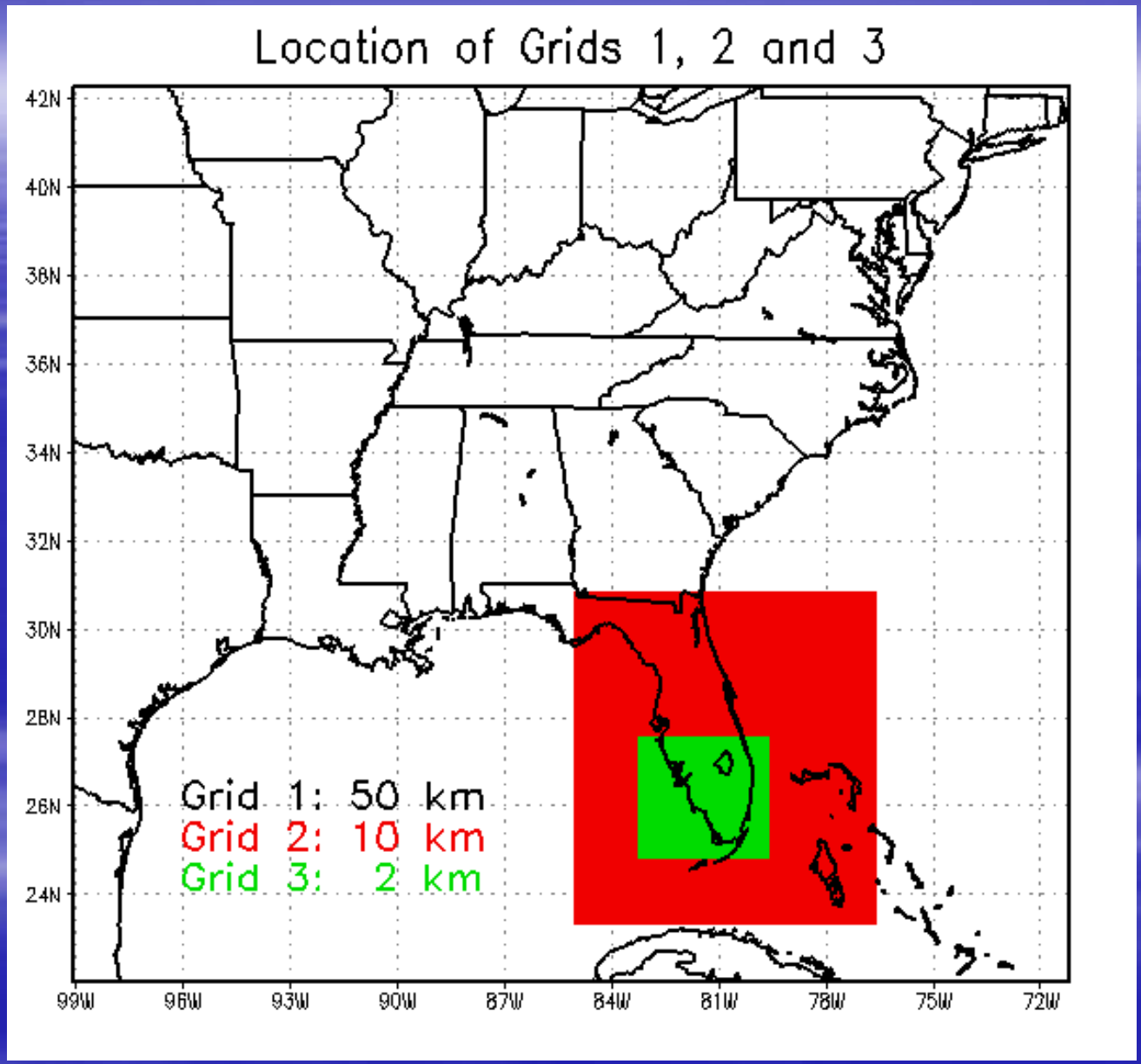


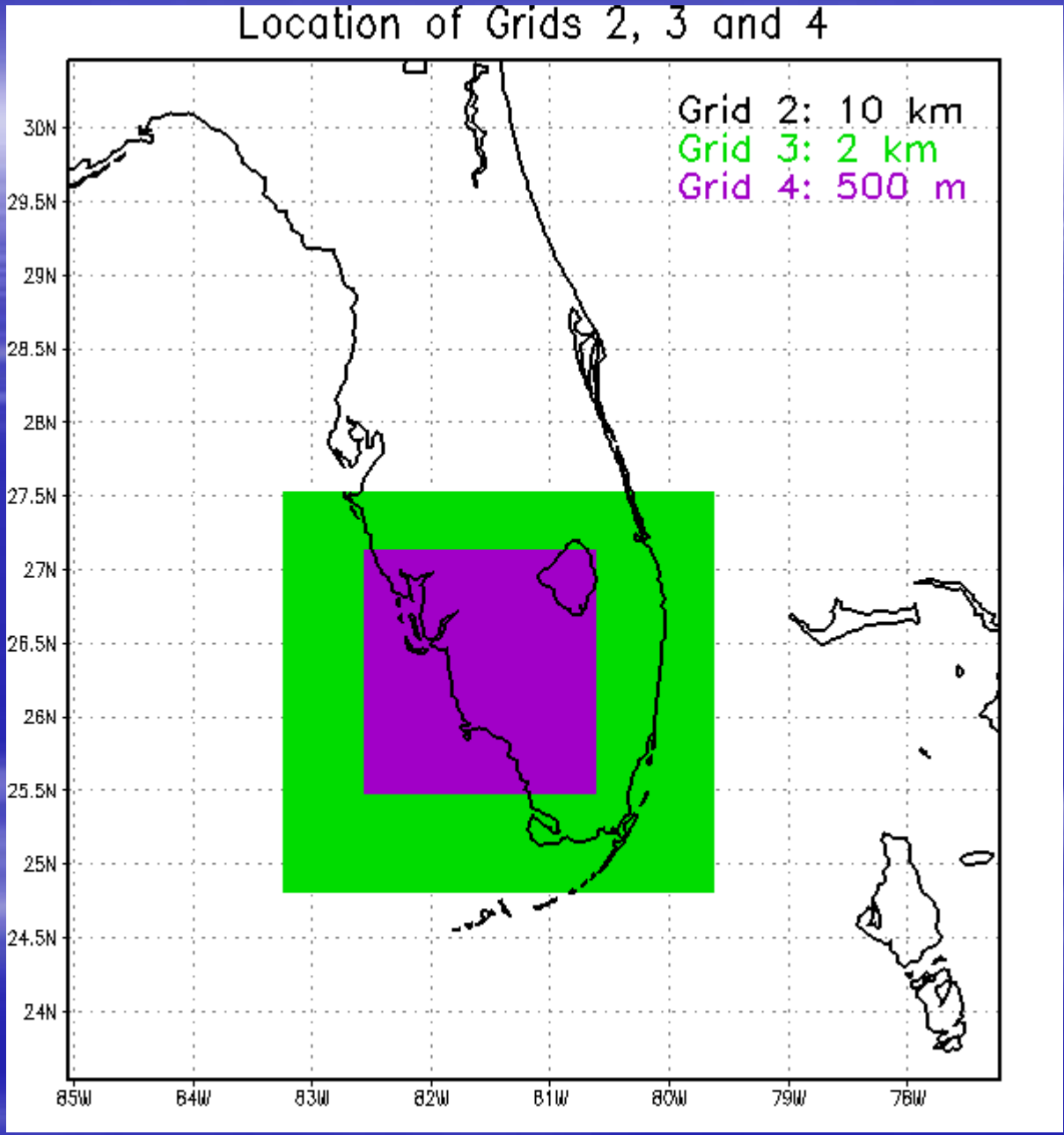
Source: NASA LaRC


Source: CF Web Page

Model Details

- Regional Atmospheric Modeling System (RAMS) developed at CSU
- 4 grids
- Horizontal grid spacing:
  - Grid 1: $\Delta x = \Delta y = 50$ km
  - Grid 2: $\Delta x = \Delta y = 10$ km
  - Grid 3: $\Delta x = \Delta y = 2$ km
  - Grid 4: $\Delta x = \Delta y = 500$ m
- Vertical grid spacing:
  - Stretched
  - 8 levels within first 1km AGL
- Initialized at 12Z with 40 km Eta data
- Simulation run for 12 hours

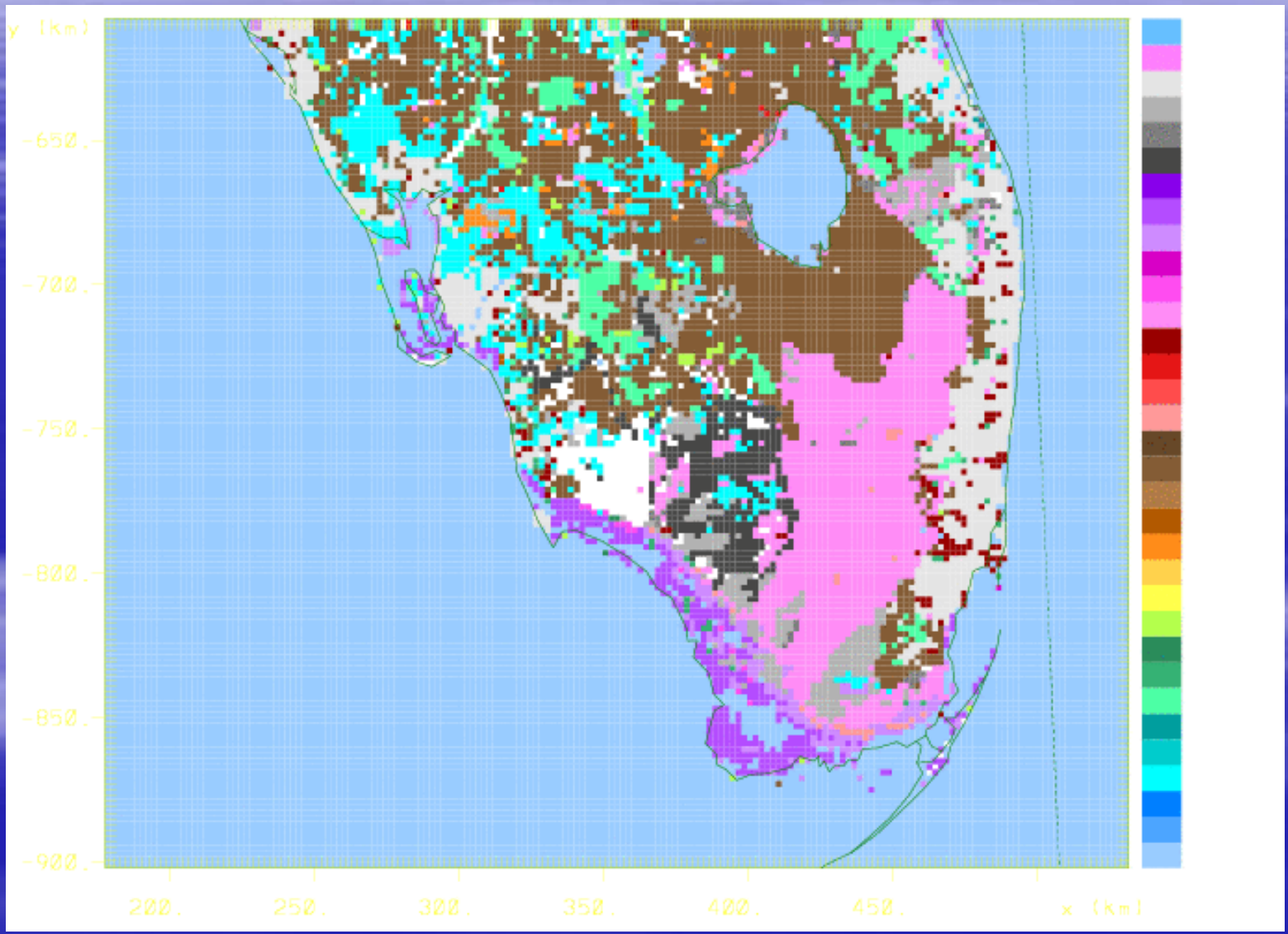

Location of Grids 1, 2 and 3
42N
40N
38N
36N
34N
32N
30N
28N
26N
24N
99W
96W
93W
90W
87W
84W
81W
78W
75W
72W
Grid 1: 50 km
Grid 2: 10 km
Grid 3: 2 km


Location of Grids 2, 3 and 4
Grid 2: 10 km
Grid 3: 2 km
Grid 4: 500 m
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
85W
84W
83W
82W
81W
80W
79W
78W

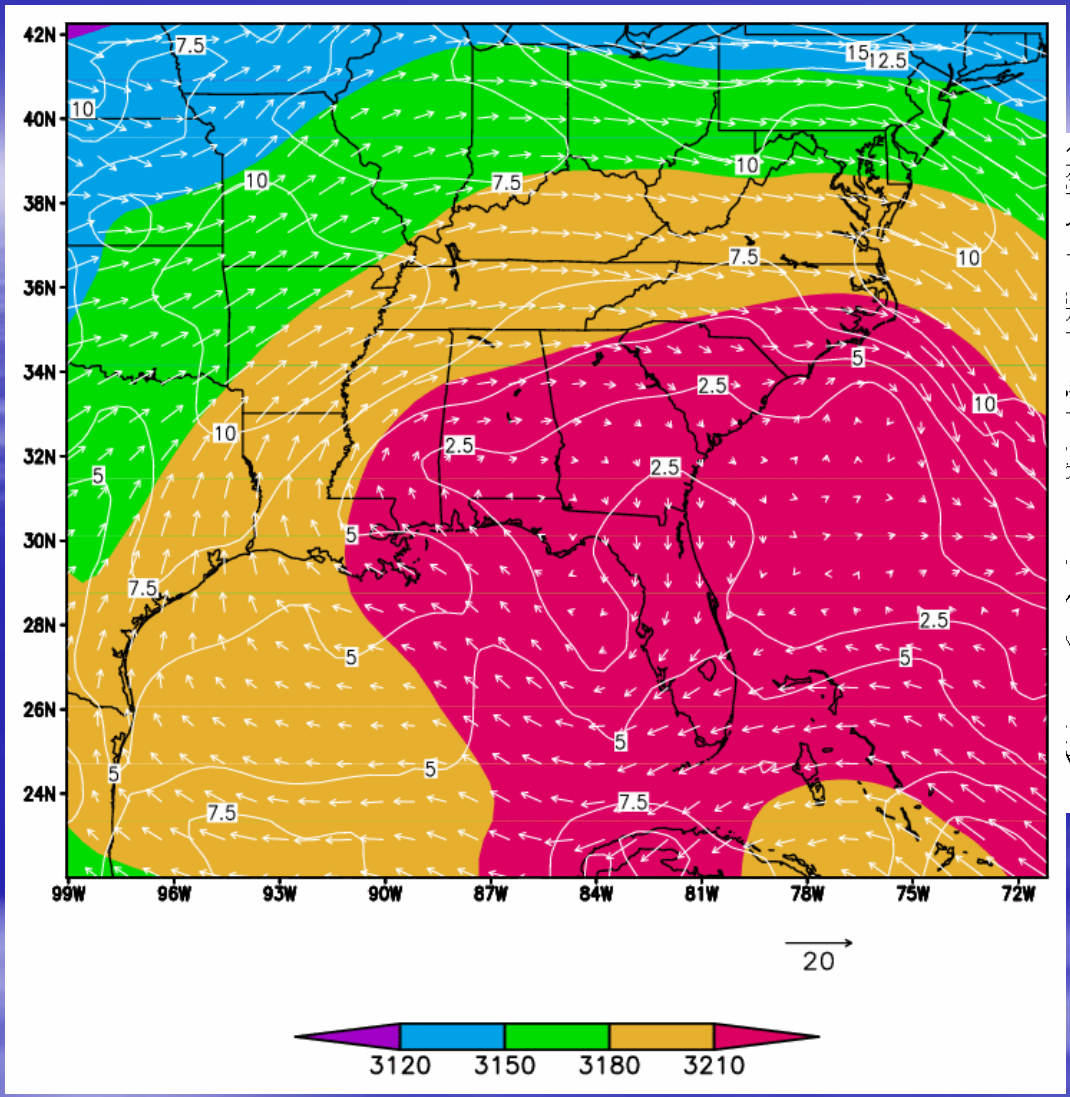
Model Details (cont)

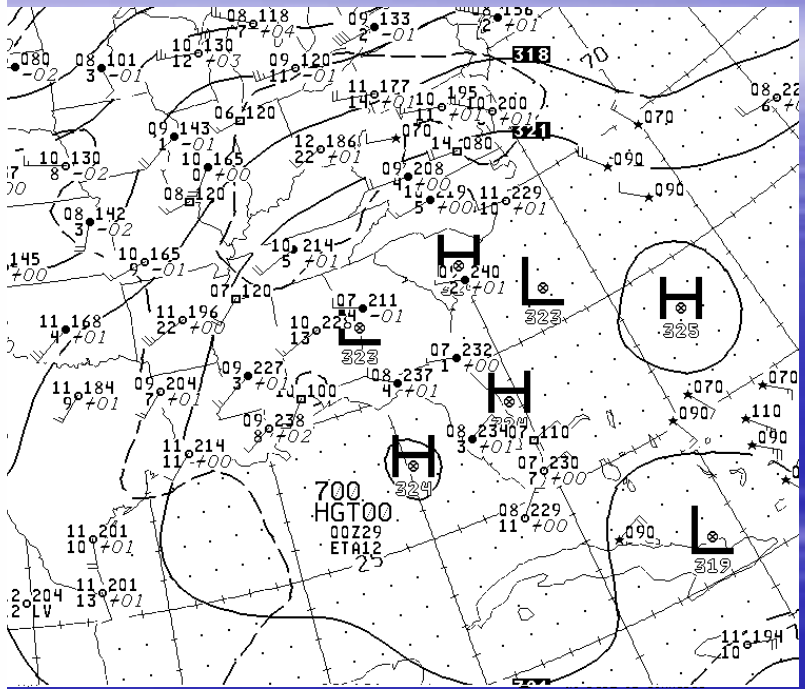
- Two-moment microphysics
- Microphysical species: cloud water, rain, pristine ice, snow, aggregates, graupel, hail
- Other microphysical aspects:
  - second cloud mode
  - CCN and GCCN
  - Saharan dust
- Sophisticated vegetation and soil model
  - 40 vegetation classes (USGS) (100m resolution)
  - include standing water

Grid 3 Vegetation



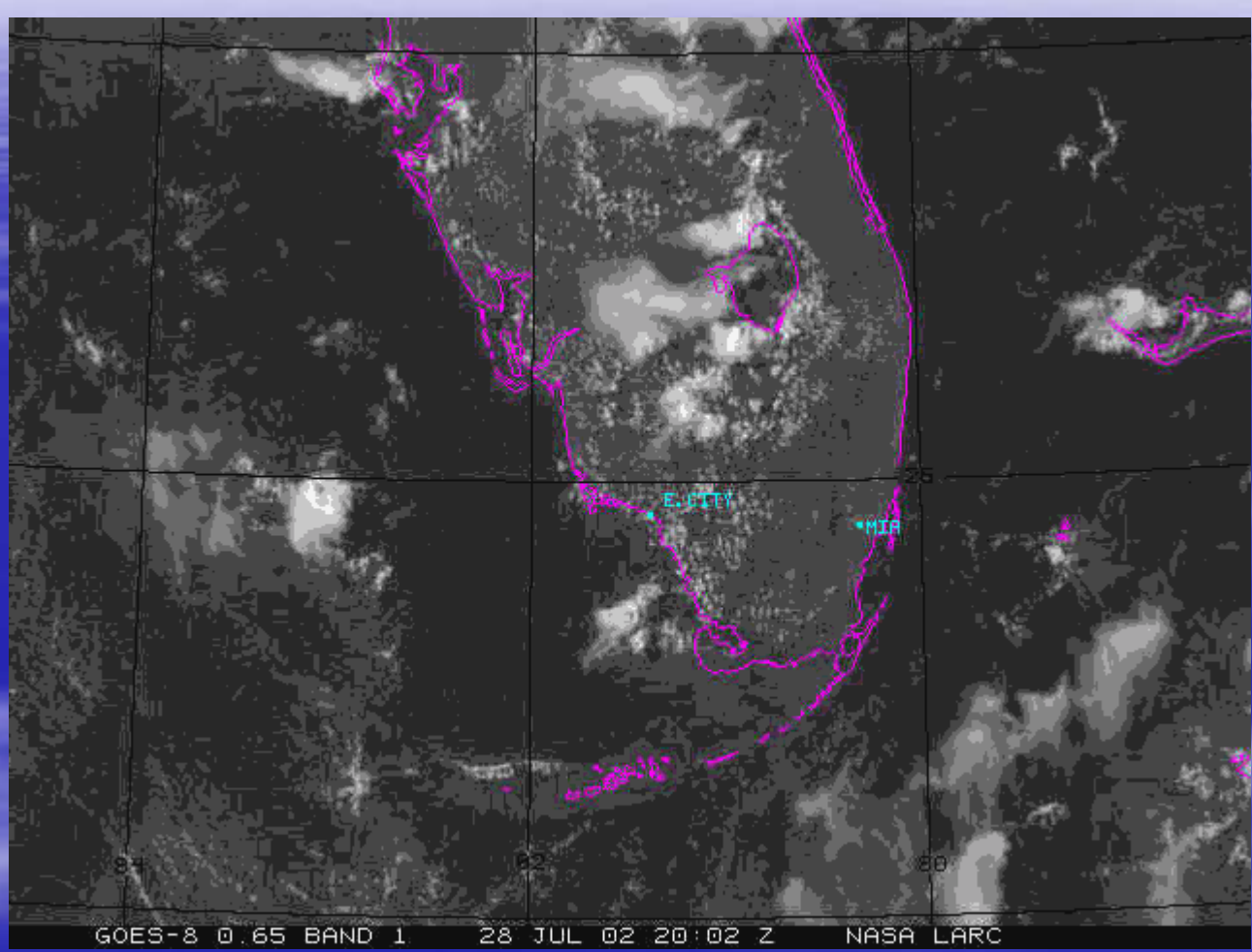
RESULTS



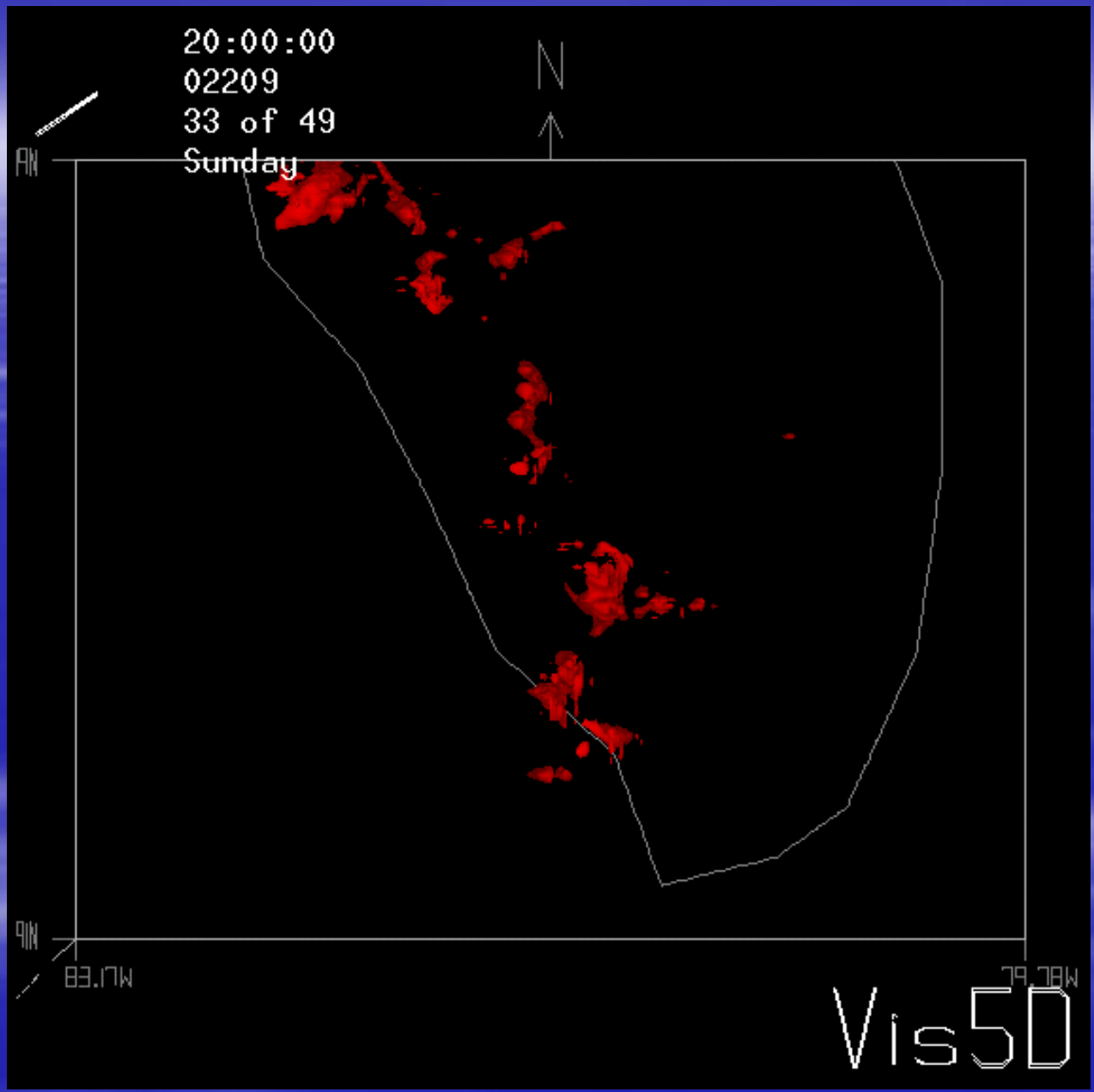


Corresponding 700 mb analysis

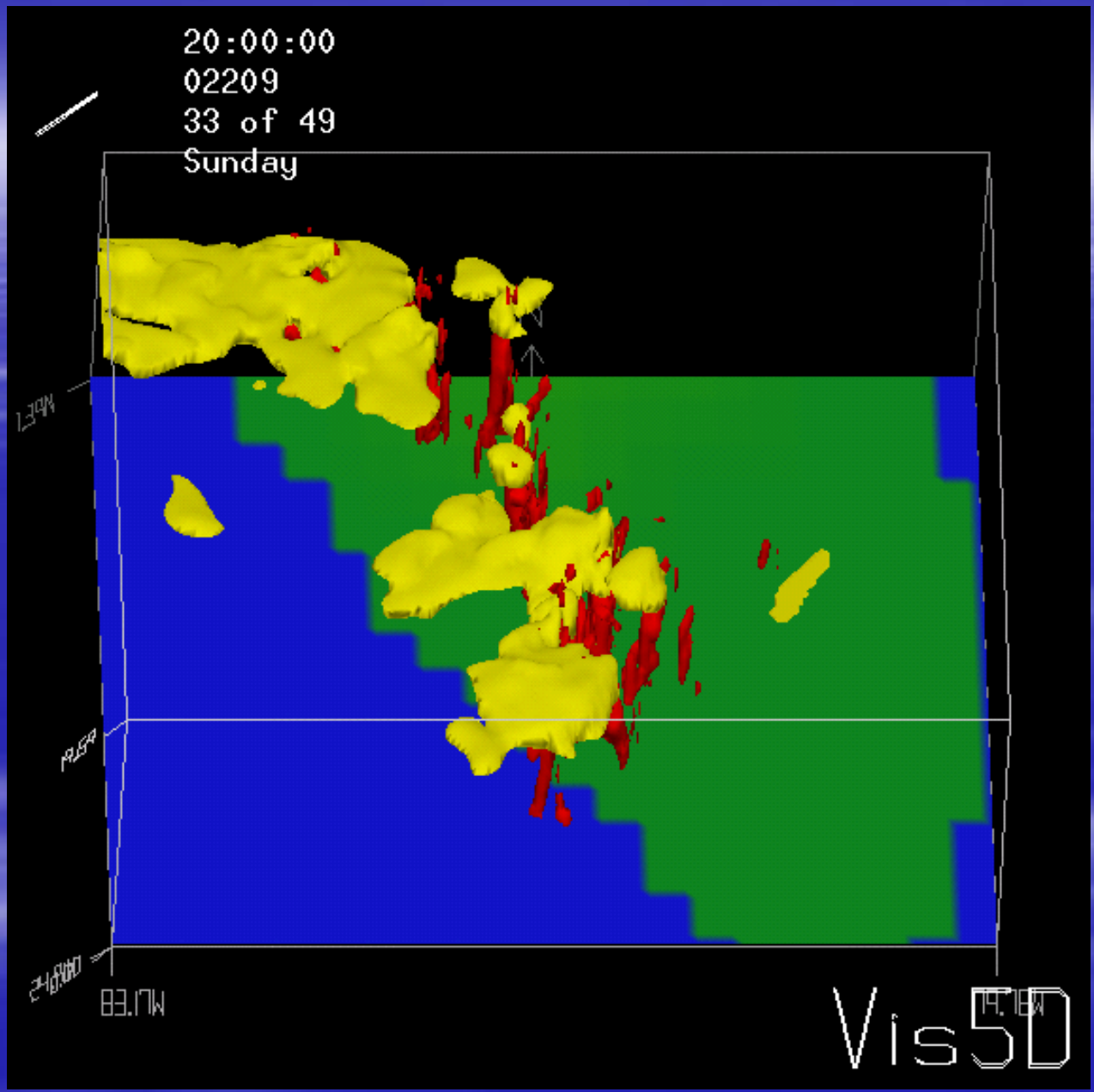
700 mb geopotential heights (color), wind speed (white contours, m/s) and wind vectors after 12 hours of simulation time (00z on 07/29)



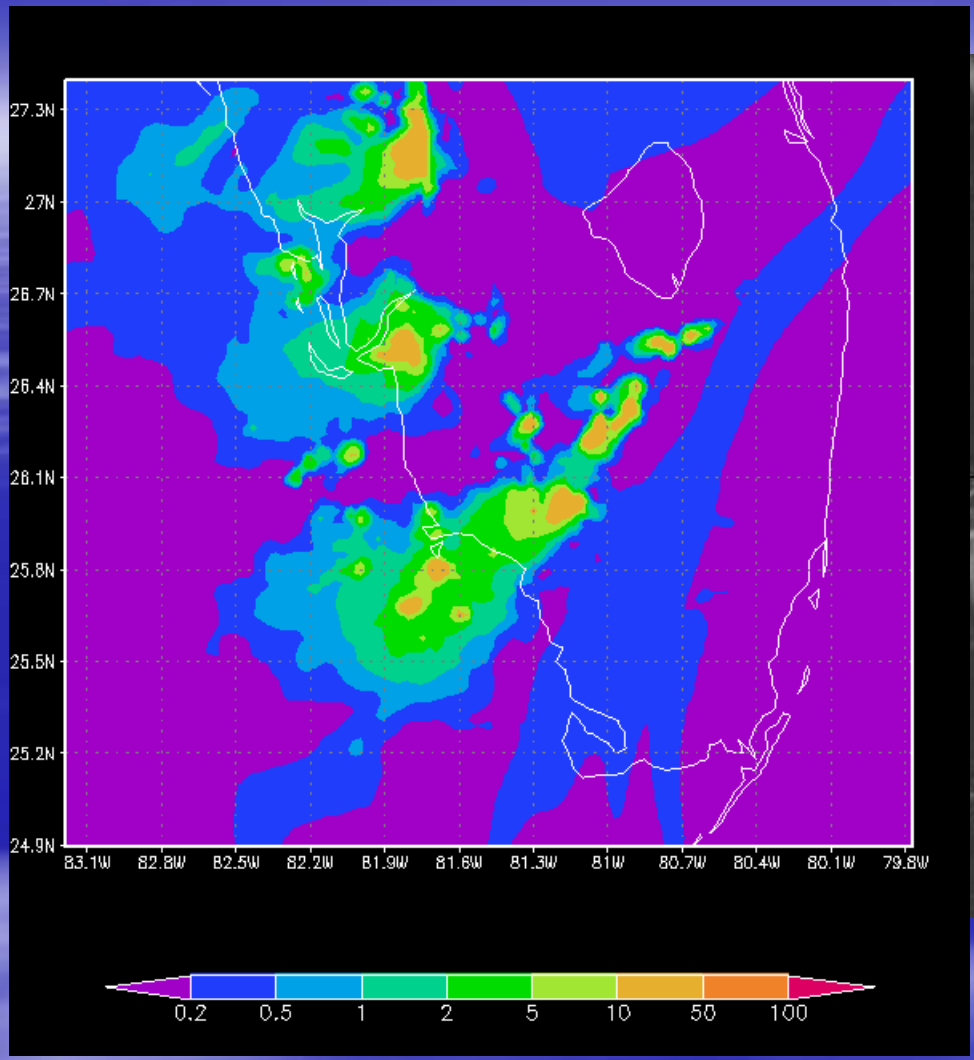
Source: NASA LaRC

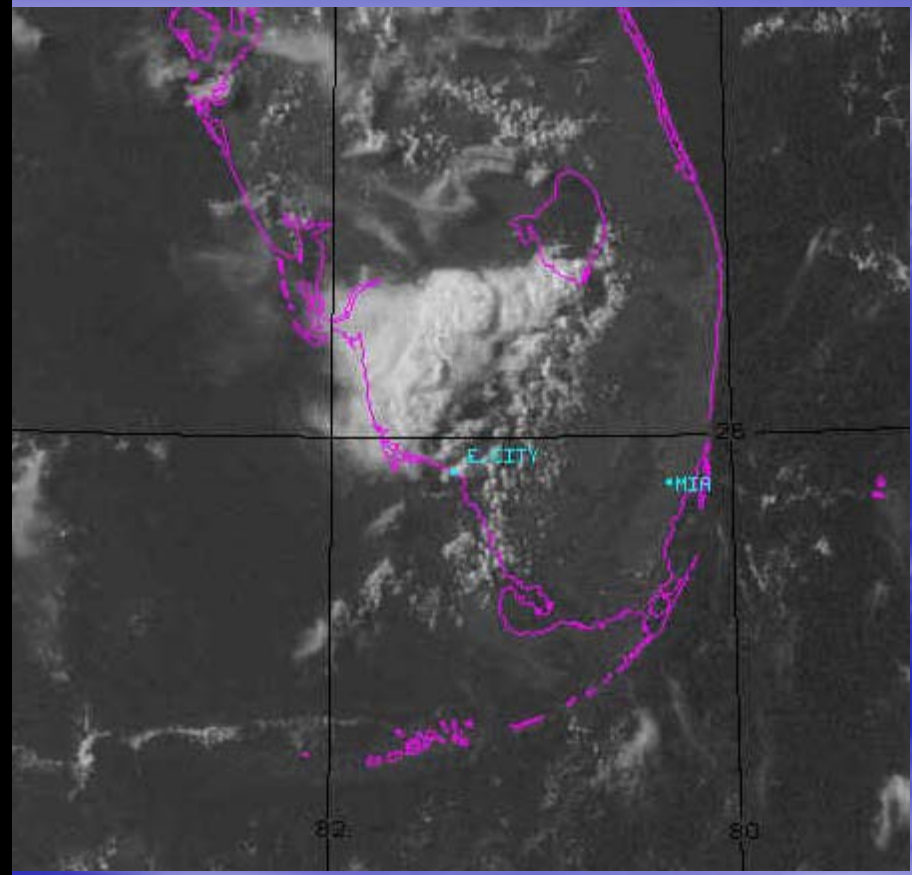


Vertical velocity (red, isosurface: 1m/s)

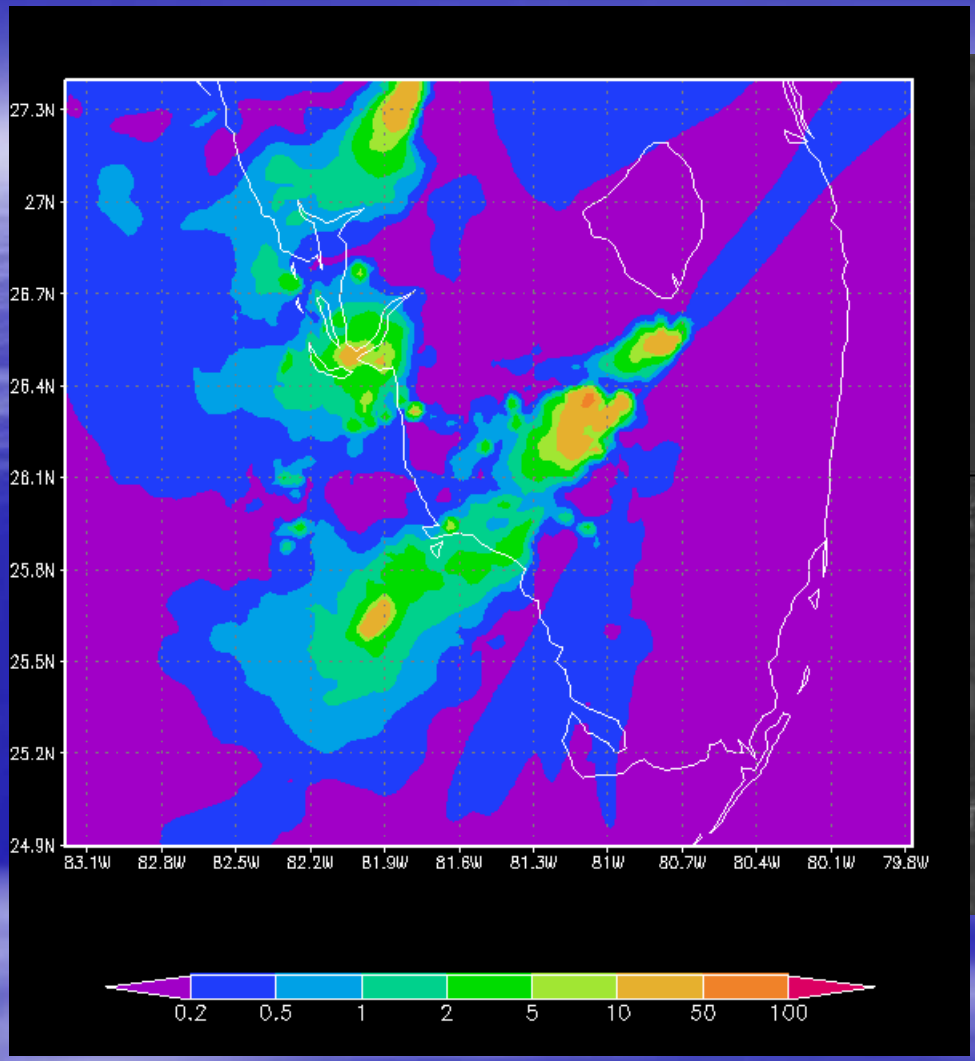


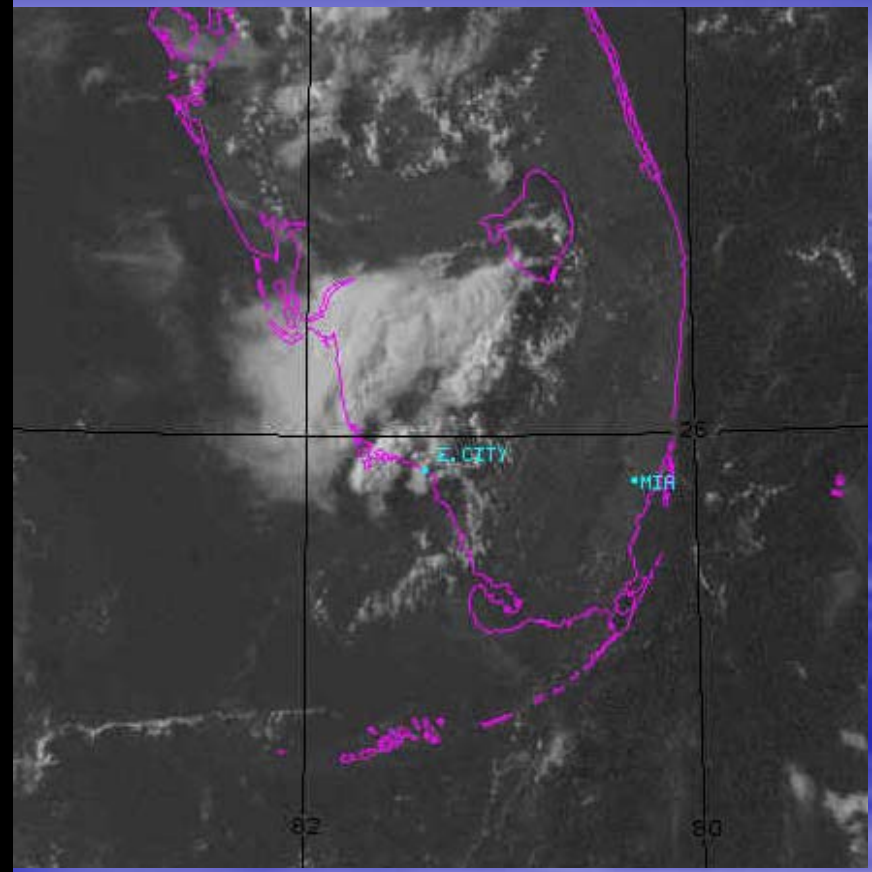
Vertical velocity (red, isosurface 1m/s) and pristine ice (yellow, isosurface 0.3 g/kg)



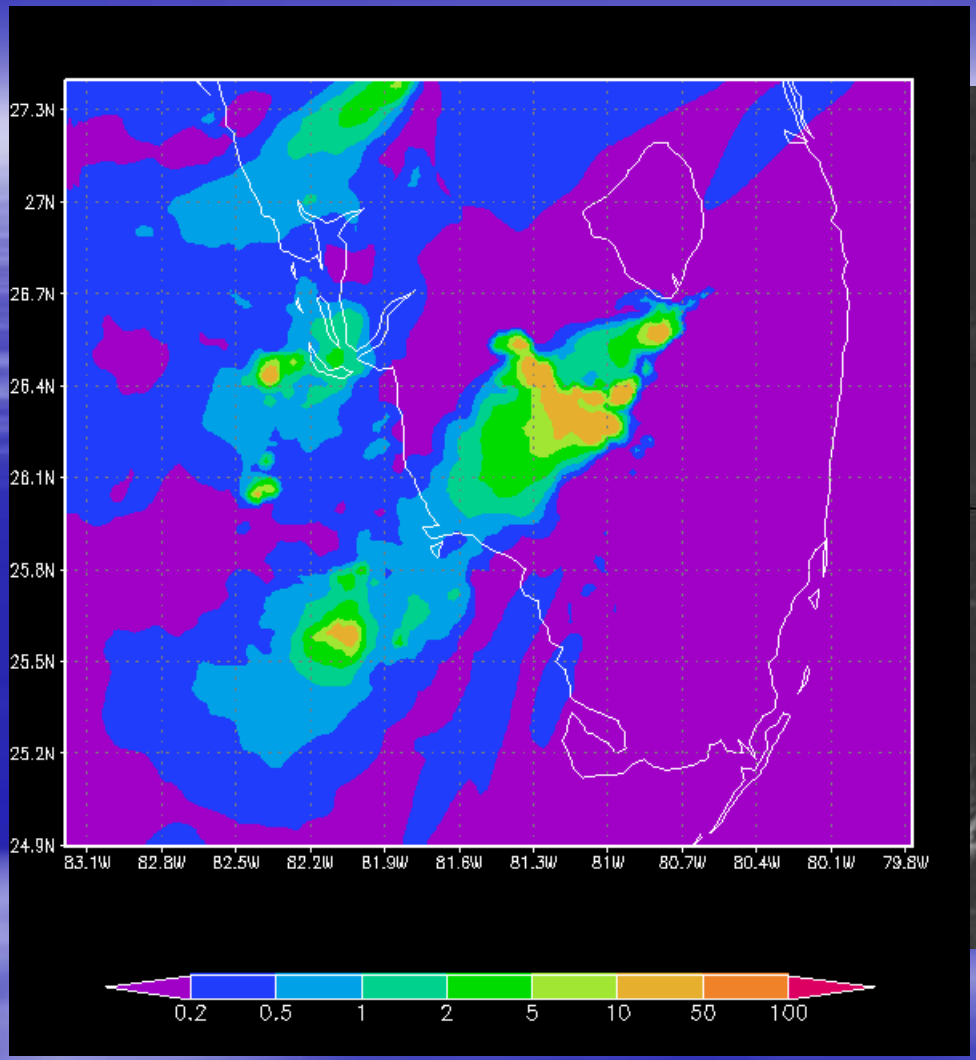


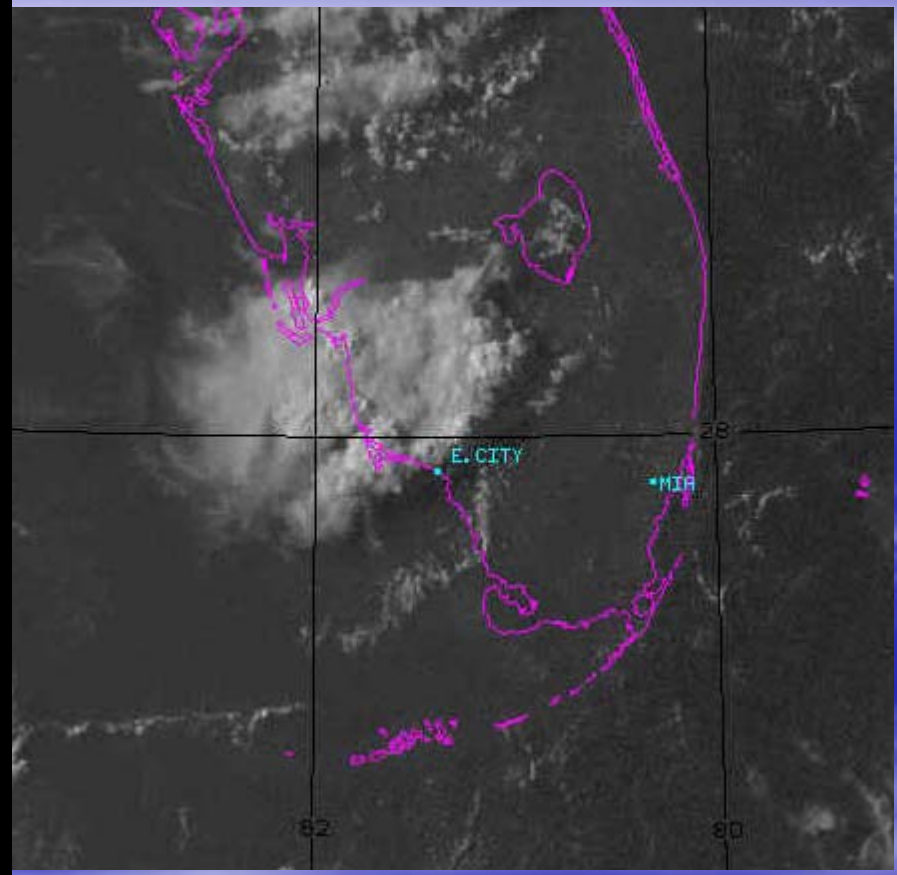
Vertically integrated condensate (mm) and visible satellite imagery at 2115Z



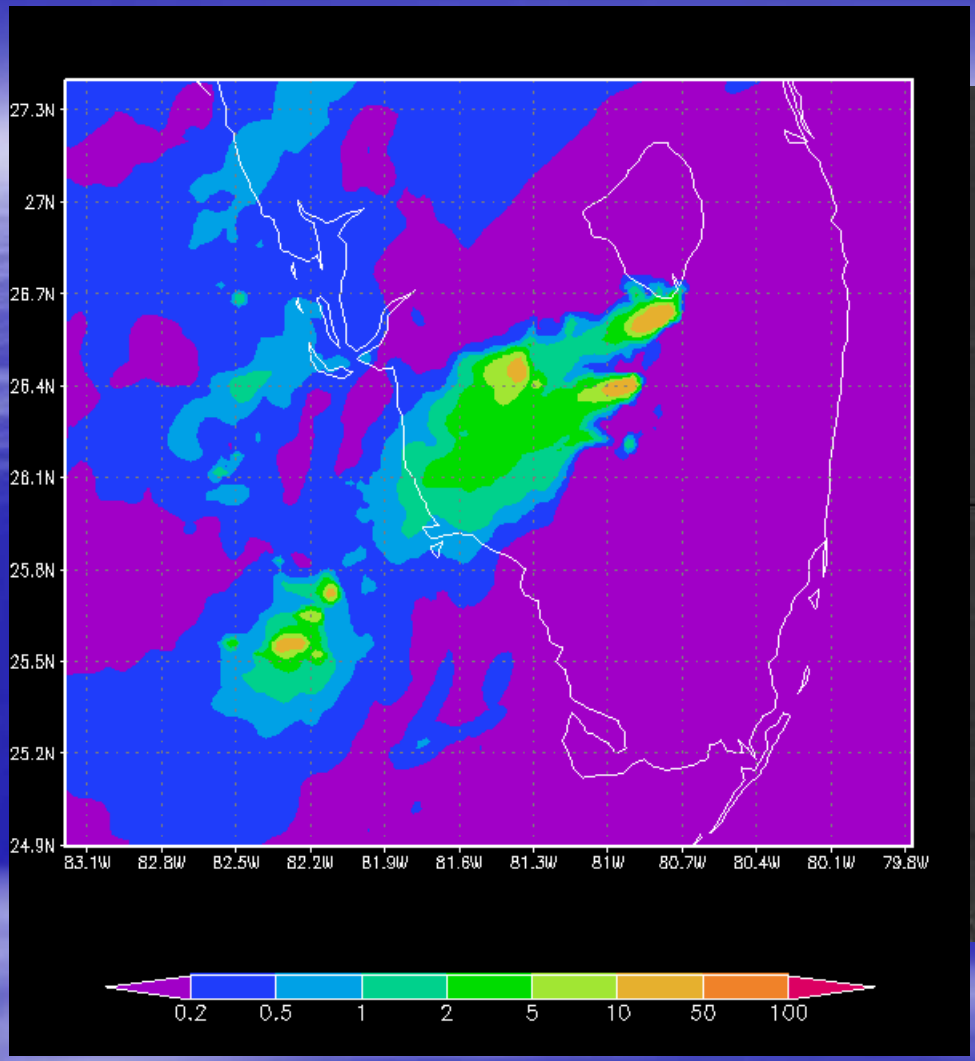


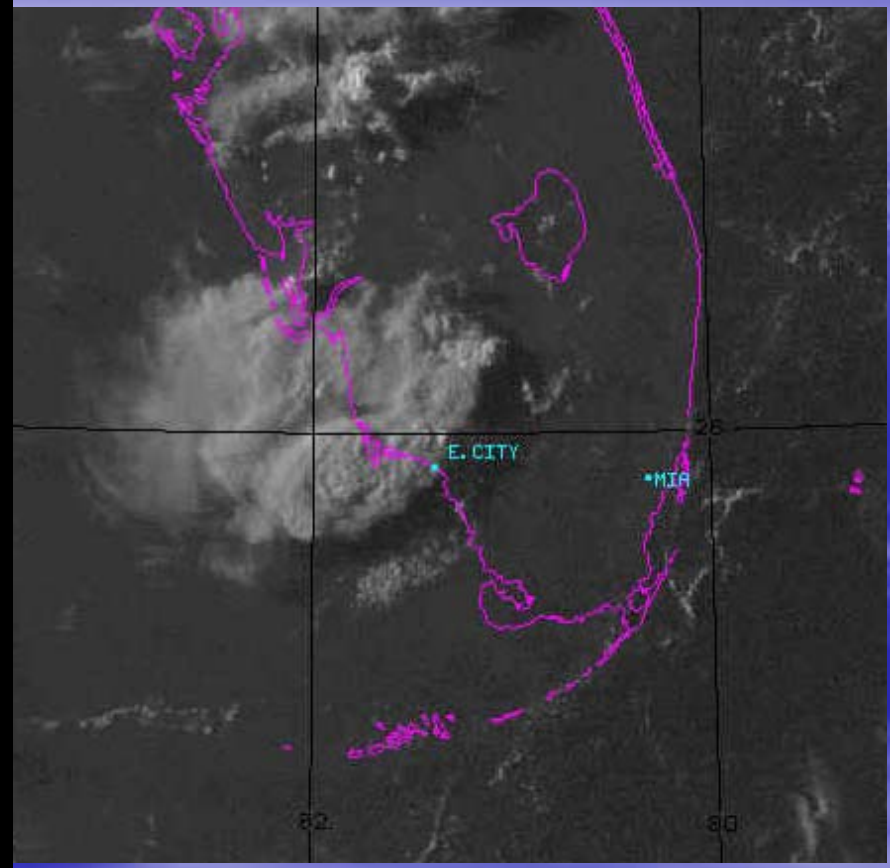
Vertically integrated condensate (mm) and visible satellite imagery at 2145Z



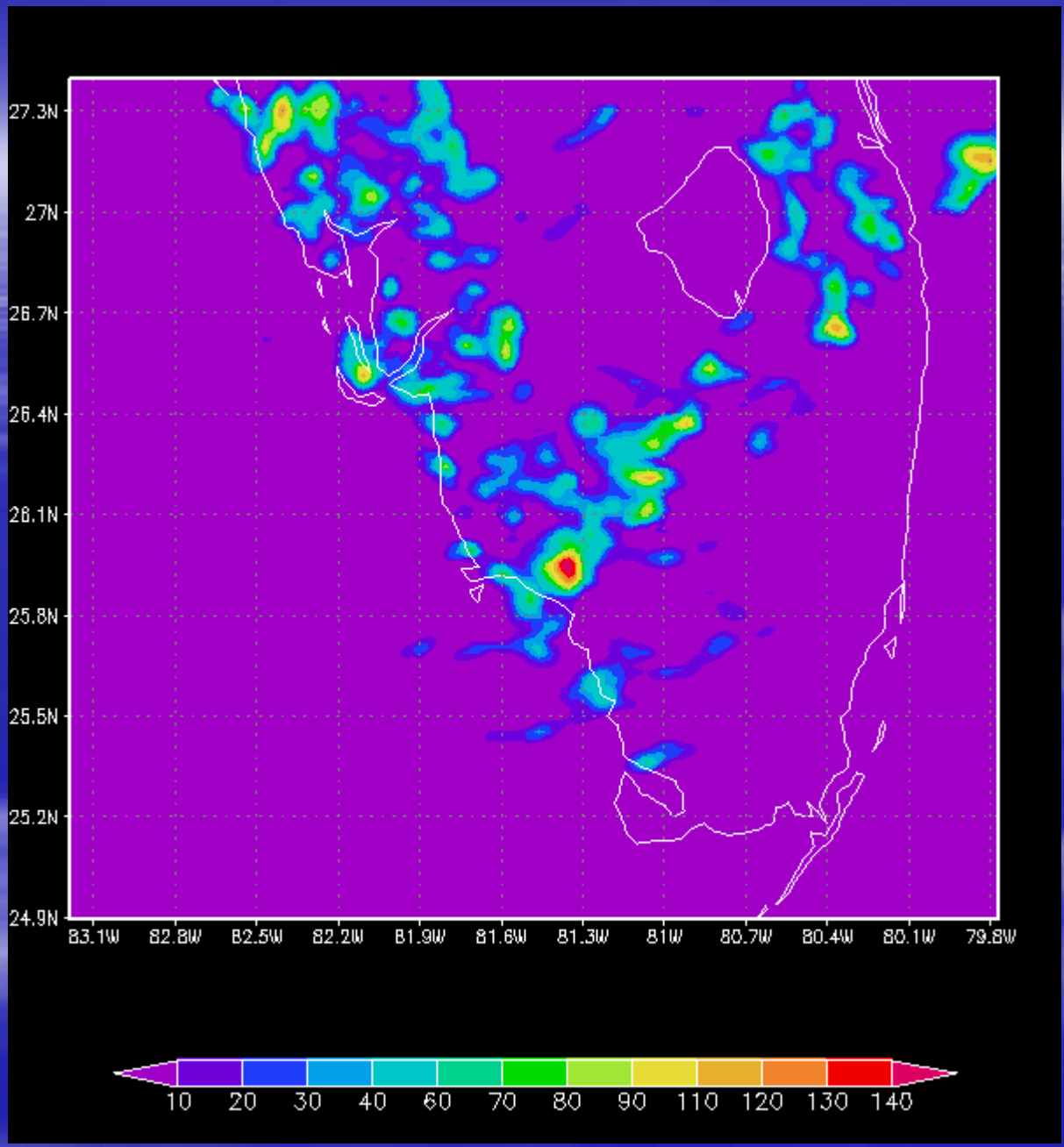


Vertically integrated condensate (mm) and visible satellite imagery at 2215Z

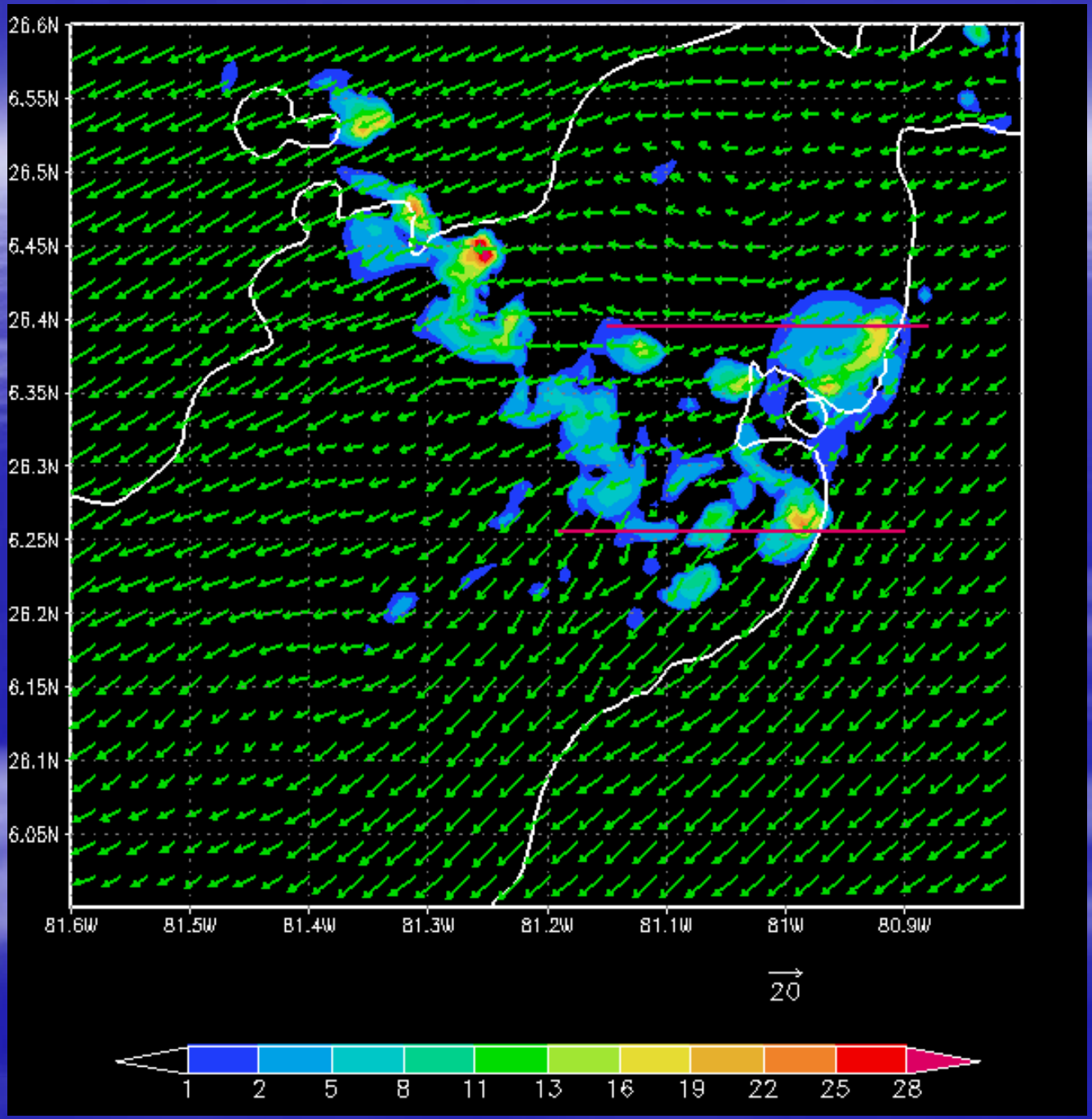




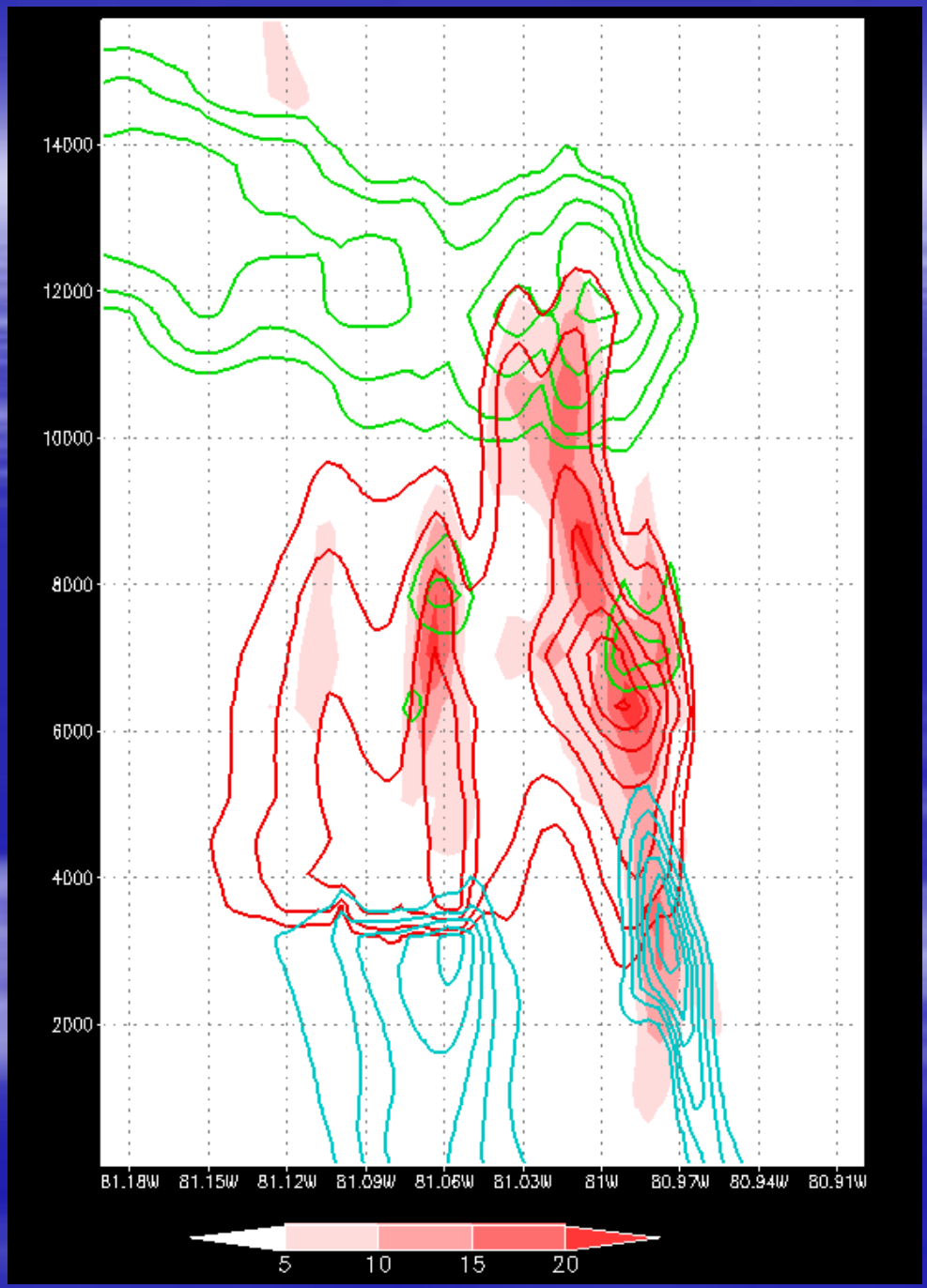
Vertically integrated condensate (mm) and visible satellite imagery at 2245Z



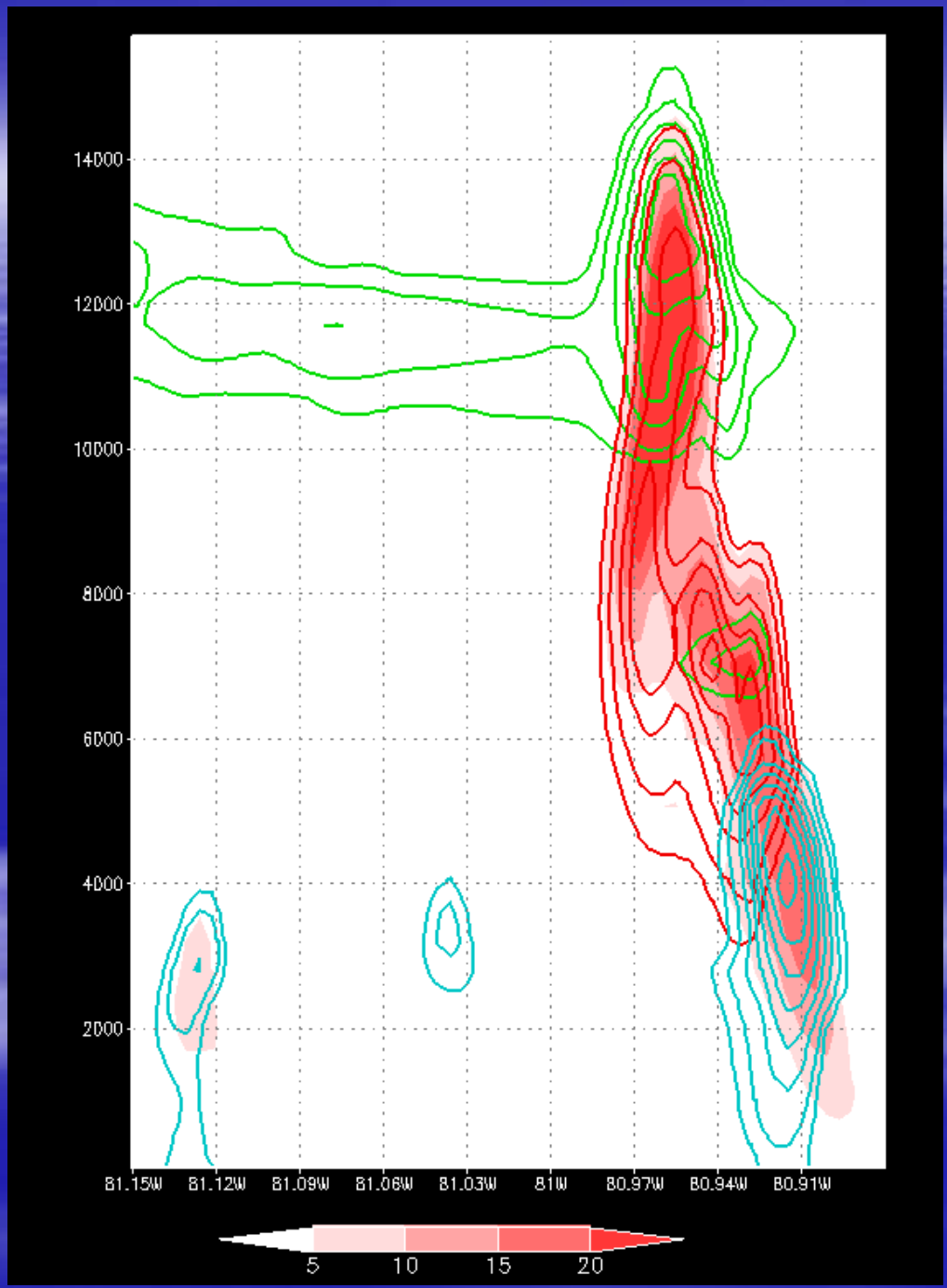
12 hour accumulated precipitation (mm)



Vertical velocity (color) and wind vectors at ~5 km AGL, and 0.3 g/kg total condensate (white) at ~10 km AGL on grid 4 at 2215 Z



Vertical velocity (shaded), pristine ice (green, 0.2 g/kg), hail (red, 1g/kg) and rain (blue, 1g/kg) mixing ratios



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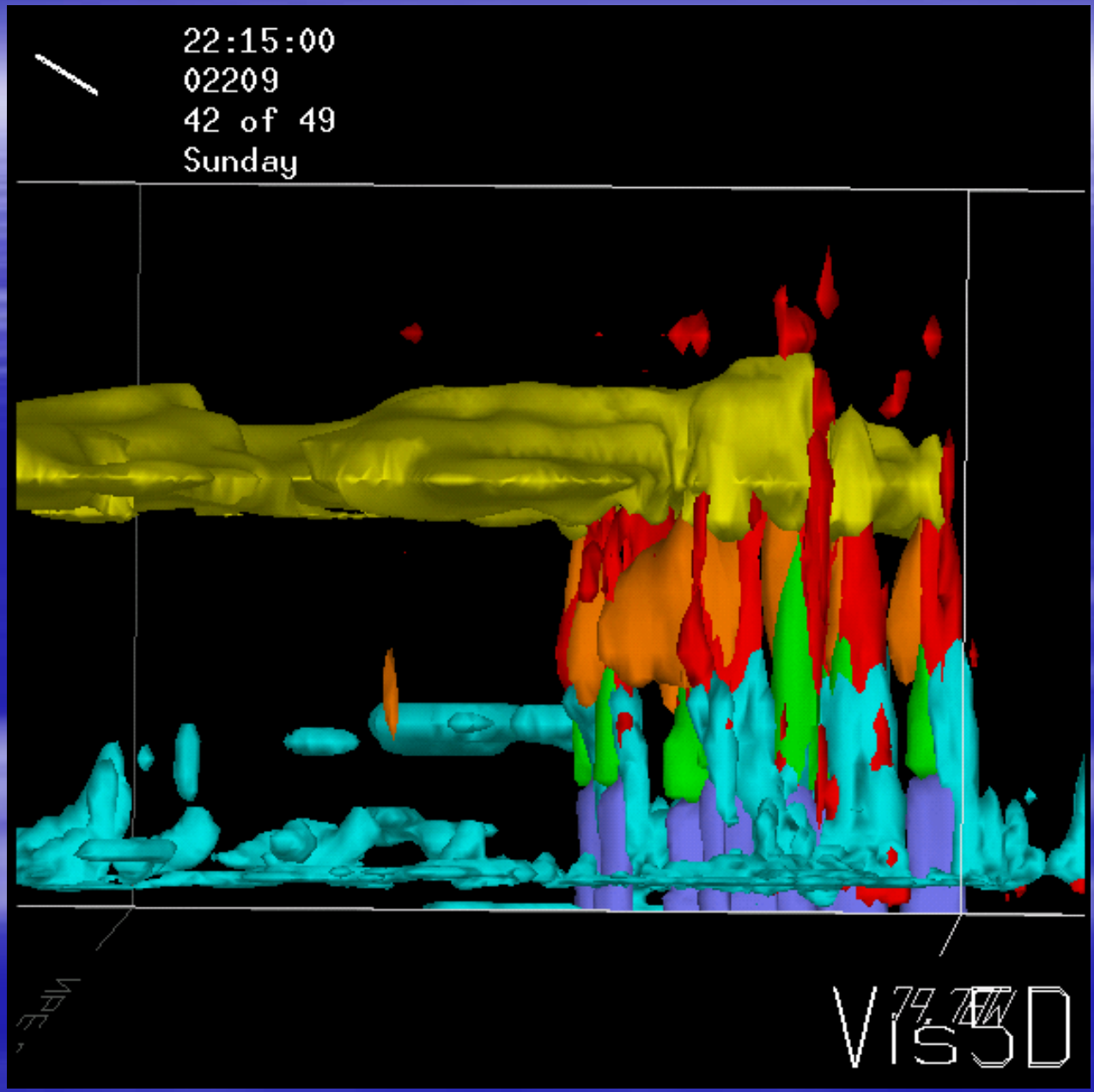


Vertical velocity (red, 1m/s), pristine ice (yellow, 0.3 g/kg), hail (green, 1g/kg), rain (mauve, 1g/kg), graupel (orange, 1g/kg) and cloud water (blue, 0.3 g/kg)

Future Plans

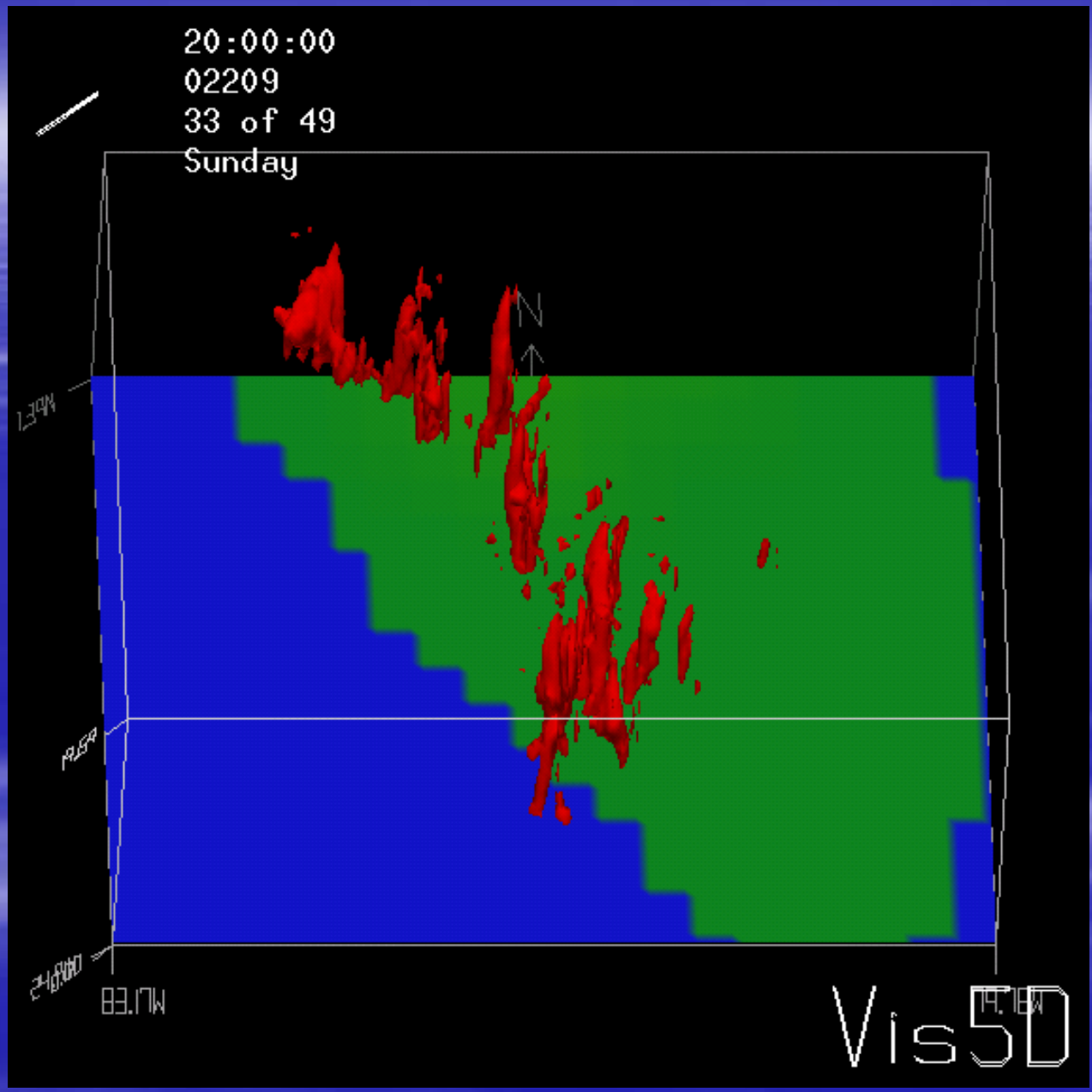
- Soil moisture and antecedent precipitation
  - several days of decent precipitation before 28 July
  - determine sensitivity of developing convection and anvil to surface characteristics
- Second cloud water mode
  - Second mode in the cloud droplet spectrum - provides better resolution of the collection process and permits simulation of the activation of GCCN.
  - slows rain production
  - affects accumulated precipitation and cold pool intensity

Future Plans (cont)

- CCN and GCCN concentrations
  - vary the concentrations based on the results from this meeting
  - RAMS allows for homogeneous initialization, vertical profile or specific source regions
  - number and mass sources and sinks – keeps track of CCN and GCCN
  - Determine sensitivity of hydrometeor mixing ratios and concentrations, precipitation rates and accumulations to CCN and GCCN variations

Future Plans (cont)

- Saharan dust
  - include as a new aerosol species in RAMS microphysics
  - dust characteristics based on results from this meeting
  - compare sensitivity of convection and subsequent anvil development in “clean” and “dirty” air
- Particle transport model
  - run with RAMS output
  - forward and backward trajectories
  - useful in determining the source of air ingested into the convective storm and its final destination
- Possible idealized simulations
- LES simulation of anvil microphysics and dynamics



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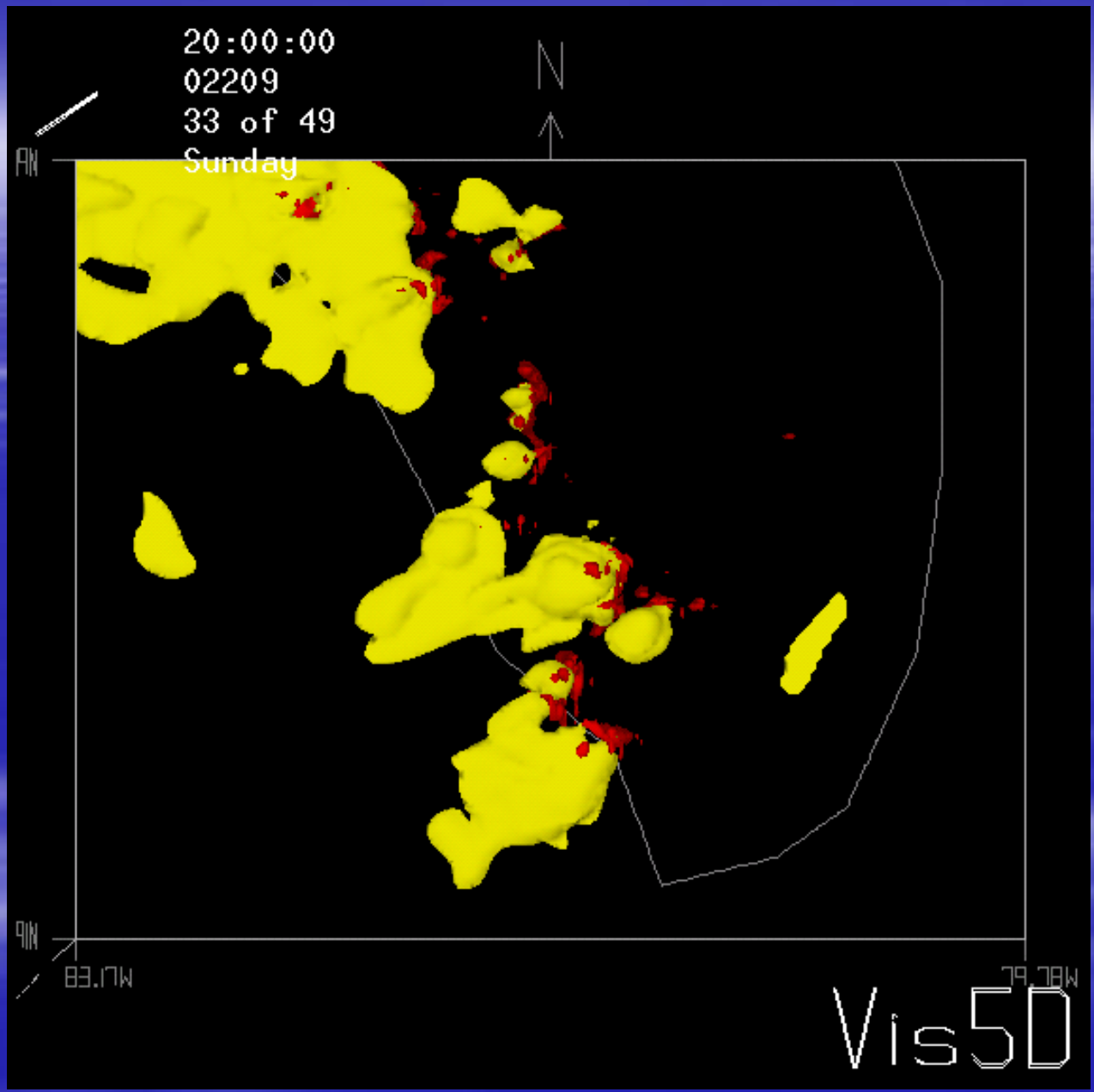

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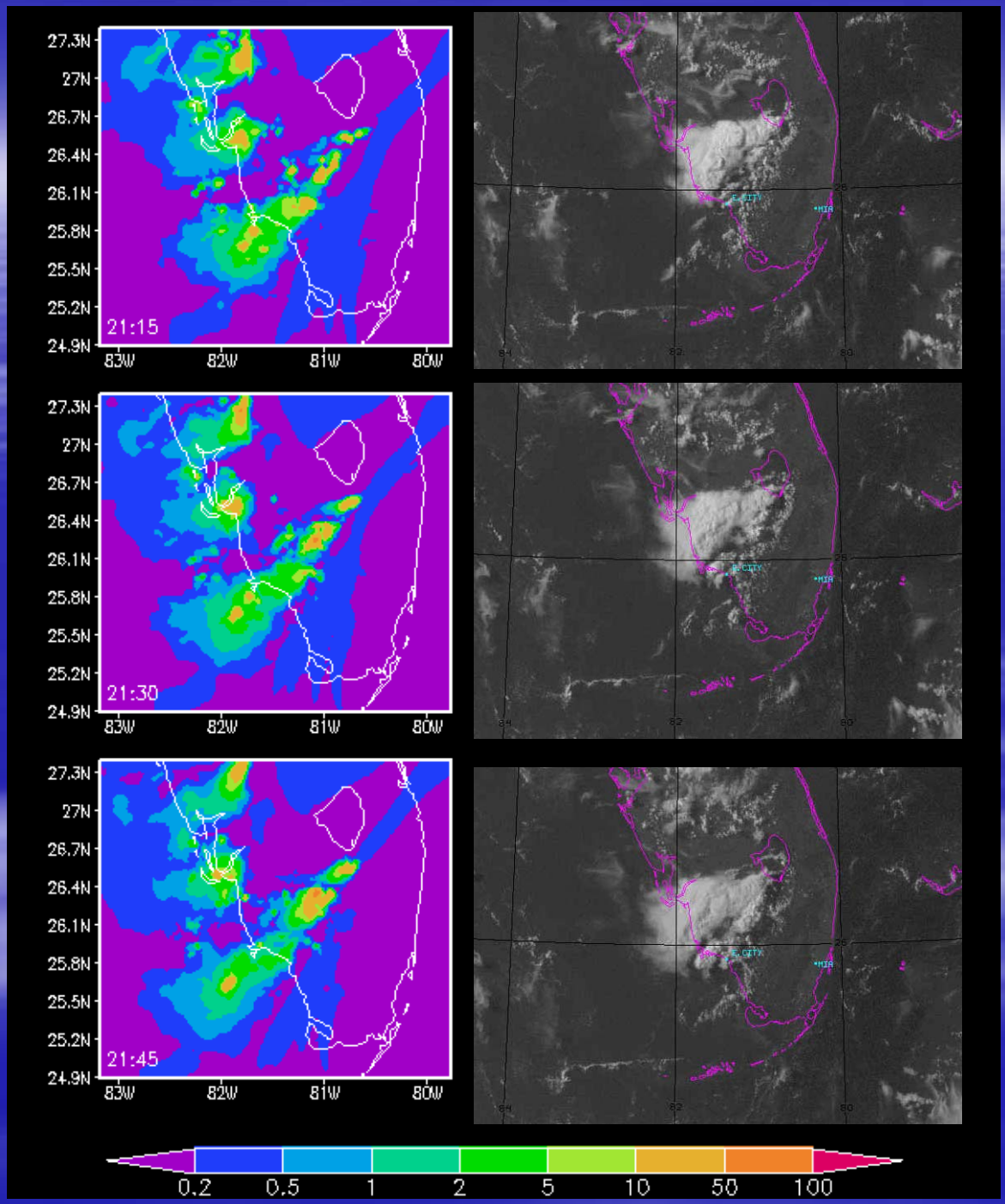

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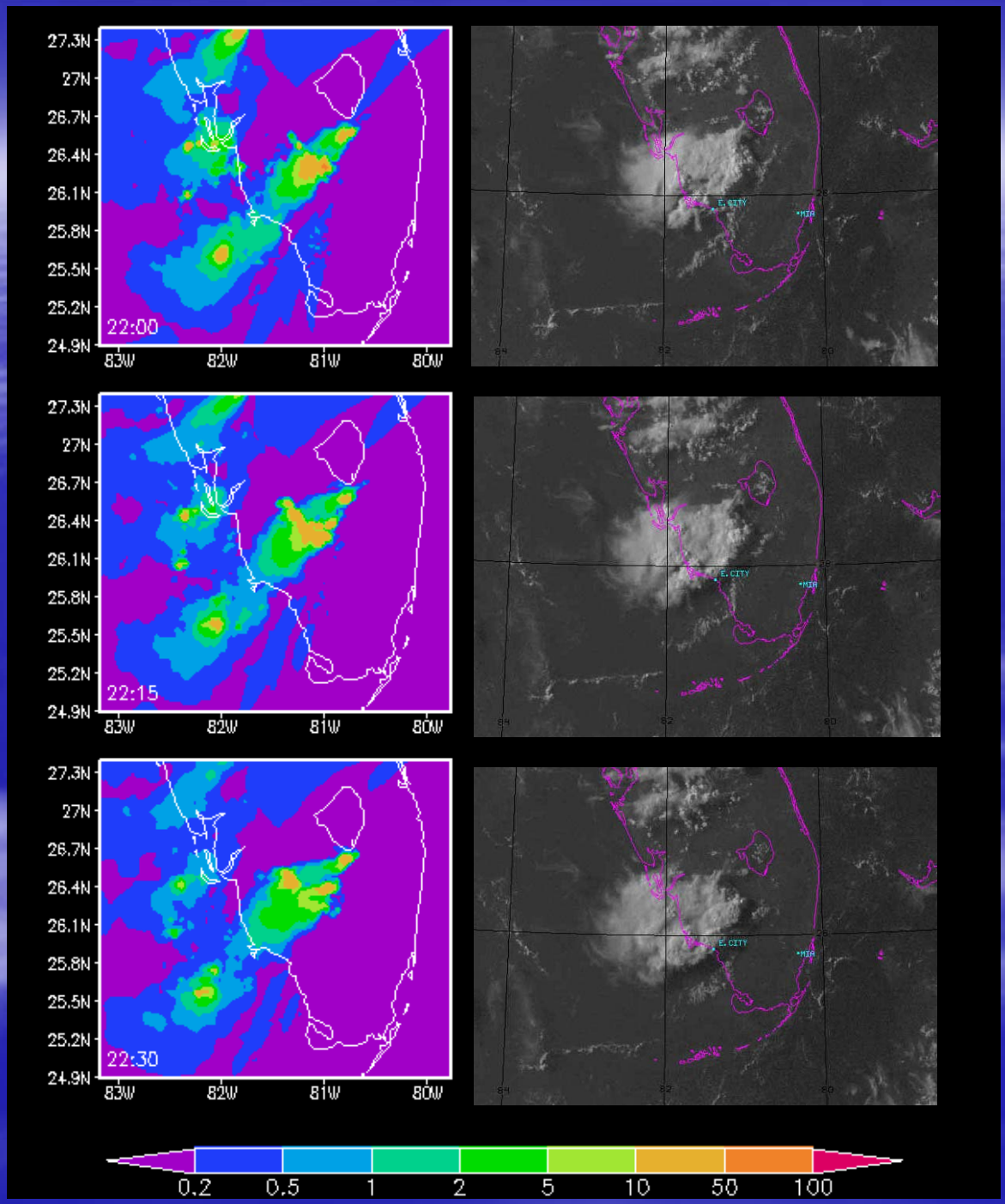

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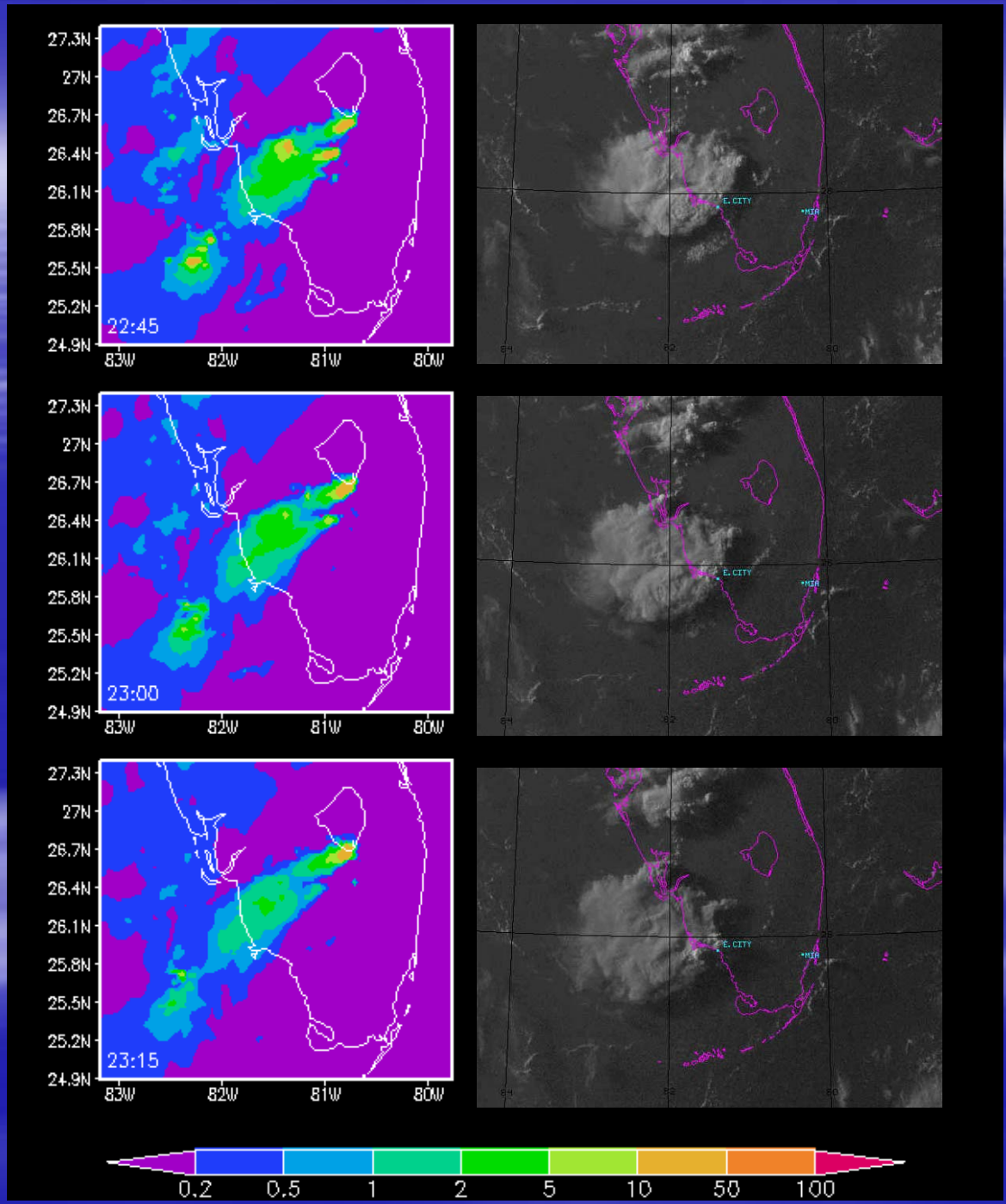

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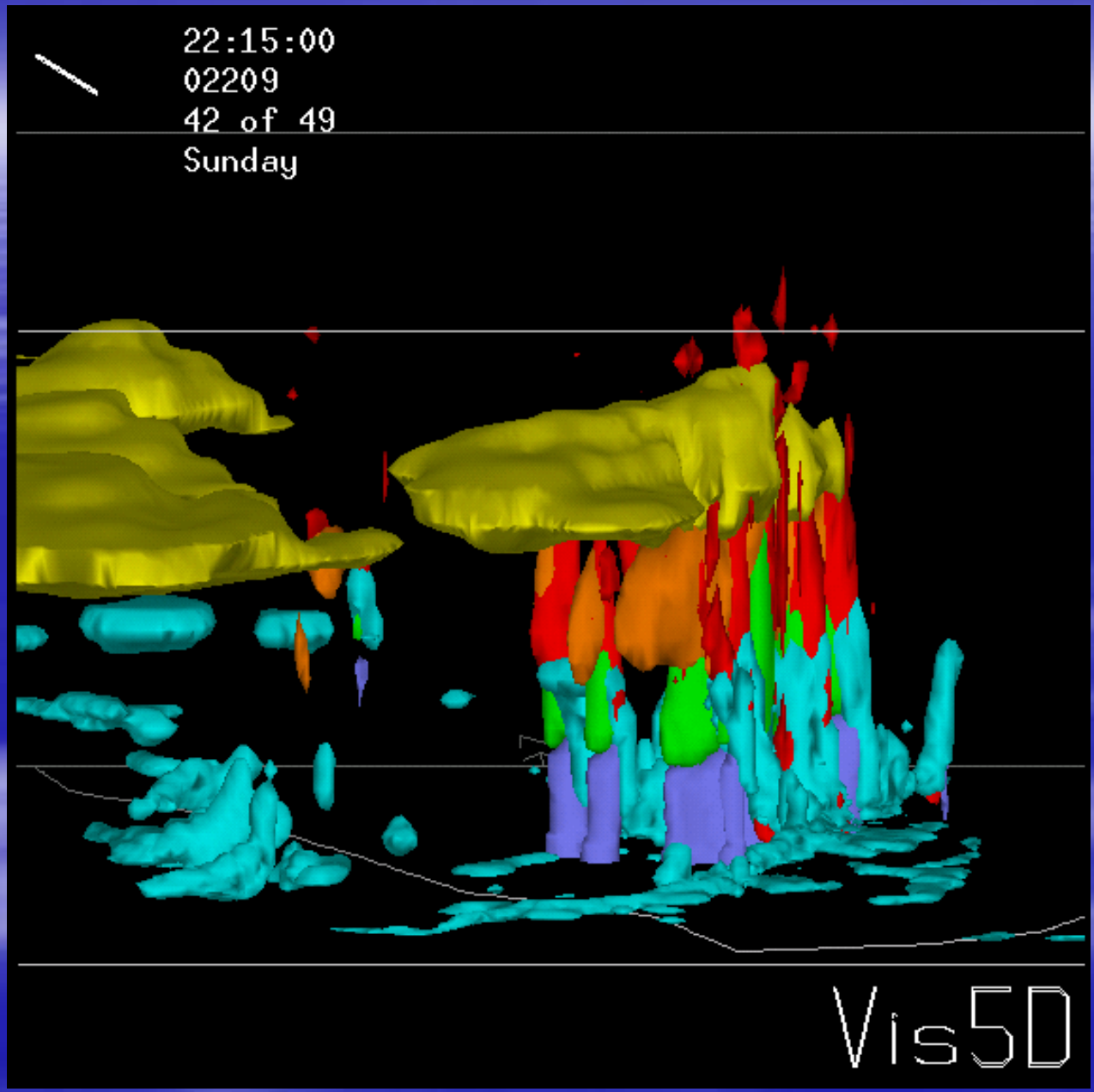

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